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Indian Standard

CODE OF PRACTICE FOR INSTALLATION OF FARM DRAINAGE TILE OR PIPE SYSTEM

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June 1981

Indian Standard

CODE OF PRACTICE FOR INSTALLATION OF FARM DRAINAGE TILE OR PIPE SYSTEM

Farm Drainage Tiles Sectional Committee, AFDC 47

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Indian Standard

CODE OF PRACTICE FOR INSTALLATION OF FARM DRAINAGE TILE OR PIPE SYSTEM

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 December 1980, after the draft finalized by the Farm Drainage Tiles Sectional Committee had been approved by the Agricultural and Food Products Division Council.

0.2 The tile drains are used in areas having high water tables or salinity problem where benefits of lowering of ground water of surface run-off justify the installation of such a system. This standard is intended to serve as a guide for proper installation of tiles in the farm for efficient utilization of the system.

0.3 In the preparation of this standard, assistance has been derived from the following publications:

ASAE R 260.2 Design and construction of sub-surface drains in humid areas. American Society of Agricultural Engineers, USA.

ASTM F 449-76 Standard recommended practice for sub-surface installation of corrugated thermoplastic tubing for agricultural drainage or water table control. American Society for Testing and Materials, USA.

James N. Luthin, Drainage of agricultural lands, American Society of Agronomy, USA.

Jan Van Schilfgarde, Drainage for agriculture, American Society of Agronomy, USA.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers the recommended practices for installation of sub-surface drainage tiles or pipes in the field.

2. TERMINOLOGY

2.0 For the purpose of this standard the following definitions shall apply. The terms, such as groove angle, bedding material, deflection, bulge, backfill material, cover, trench width and trench depth are illustrated in Fig. 1.

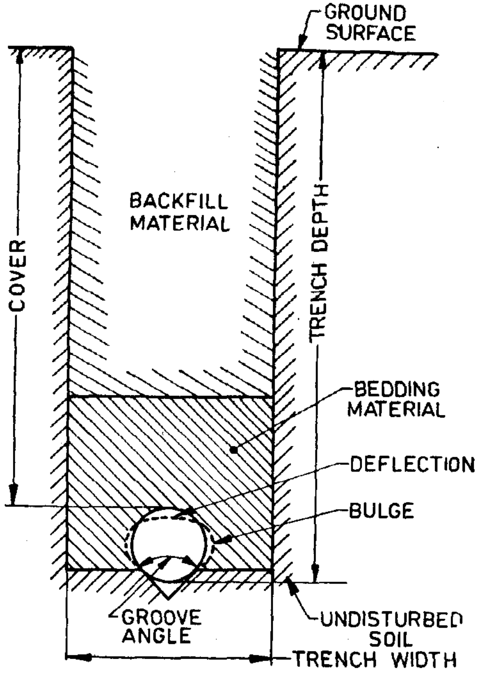


FIG. 1 TERMINOLOGY

2.1 Arid-Type Drainage — Removal of excess water and salt in arid regions at the rate that will permit successful and perpetual agriculture in the root zone depth.

2.2 Bedding — The earth foundation of the trench together with the selected material around and over the tile or pipe including envelope and filter material where used.

2.3 Blinding — The placement of bedding material over and on the sides of the tiles or pipes to ensure proper alignment and protection of tiles or pipes during backfilling.

2.4 Cradle — A prefabricated rigid structure designed to provide trench bottom support for the tile or pipe when soil support is inadequate.

2.5 Envelope — Formed with graded permeable granular material, such as sand and gravel, that is placed around the tile or pipe for bedding purposes instead of a formed groove in the trench bottom or to improve the flow of ground water into the drain. It may also be designed as a filter.

2.6 Filter — A layer or combination of layers of graded pervious materials designed and placed in such a manner as to provide drainage and yet prevent the movement of soil particles with seepage water.

2.7 Humid-Type Drainage — Lowering high water table in humid region sufficiently to provide adequate aeration for plant growth.

2.8 Mineral Soil — Soil containing maximum of 30 percent organic matter by mass provided the mineral fraction is minimum of 60 percent of clay, or maximum of 20 percent organic matter by mass provided the mineral fraction has no clay, or less than a proportional content of organic matter between 20 and 30 percent if the clay content of mineral fraction is maximum of 60 percent.

2.9 Organic Soil — Soil containing minimum of 30 percent organic matter by mass provided the mineral fraction is minimum of 60 percent of clay, or minimum of 20 percent organic matter by mass provided the mineral fraction has no clay, or a proportional content of organic matter between 20 and 30 percent if the clay content of mineral fraction is maximum of 60 percent.

NOTE — It is general rule that a soil is classed as an organic soil either if more than one half of upper 80 mm of soil is organic or if oraganic soil material of any thickness rests on rock or on fragmental material having voids filled with organic matter.

2.10 Pre-Envelope — The material applied on smooth or corrugated plastic pipe before its installation in the trenches and are enveloped in manufacturing process of the tile or pipe.

2.11 Stretch — The increase in length of the plastic pipes caused by tension forces during installation. It is expressed as a percent increase of the length prior to installation.

NOTE — Stretch differs from elongation in that elongation is a material test and stretch is an installation test.

2.12 Tile — A conduit installed beneath the ground surface and which collects and/or conveys drainage water. This is also known as pipe.

3. GENERAL

3.1 Application of Drain System — The conditions, where sub-surface tile drain system can be applied are given under **3.1.1** and **3.1.2.**

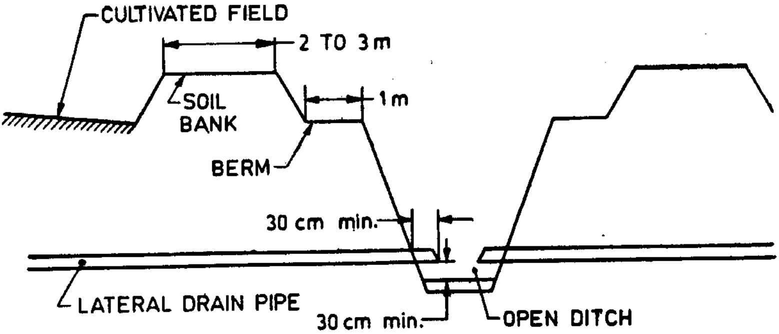
3.1.1 Areas having a high water table where benefits of lowering or controlling ground water or surface run-off justify the installation of such a system.

3.1.2 All lands to be drained shall be suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system. The drainability and treatment of saline and alkali soils shall be considered where this is a problem.

3.2 Layout — This consists of types of pipe drain system and its patterns.

3.2.1 *Types of Pipe Drain System* — Two types of pipe drain system are commonly used.

3.2.1.1 *Singular system* — The system in which each drain line has its own outlet into an open ditch (*see* Fig. 2).



NOTE — The collector drains and the soil bank should be so spread that it could be used as a path-way particularly for machines and human movement and for cleaning the drains.

FIG. 2 SINGULAR SYSTEM

3.2.1.2 *Non-singular system* — The system in which the lateral drain lines discharge into a collector pipe line (*see* Fig. 3).

NOTE — Sometime several collectors may discharge into a larger collector pipe line, and so on. Thus, composite systems of the first, second, etc, order can be formed. Lastly, the whole system has single outlet.

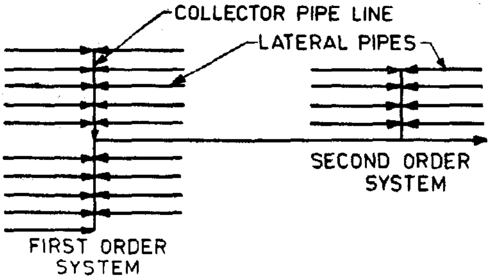


FIG. 3 NON-SINGULAR SYSTEM

3.2.2 *Pattern of Pipe Drain System* — Following patterns are commonly used in conjunction with the types of pipe drain system.

3.2.2.1 *Gridiron or parallel pattern* — A form of layout of a system of drains, generally used for flat land(s) with uniform slope having fairly homogeneous soil with a more or less uniform need of drainage. The field drains are constructed in parallel lines along with the direction of the slope and join the main drain at its bottom (*see* Fig. 4).

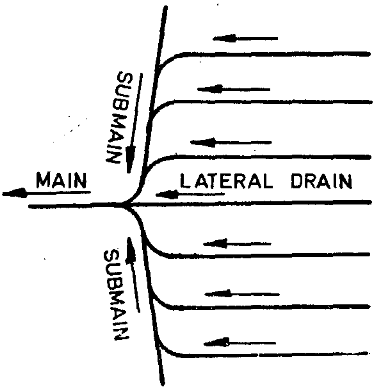


FIG. 4 GRIDIRON OR PARALLEL PATTREN

3.2.2.2 *Herring bone pattern* — A form of layout of a system of drains, generally used for land(s) lying on both sides of a narrow depression or swale and consisting of a main or sub-drain along with the depression with parallel lines of field drains sloping towards the main drain and joining it at staggered intervals (*see* Fig. 5).

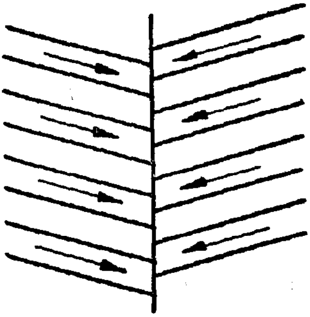


Fig. 5 Herring Bone Pattern

3.2.2.3 *Composite pattern* — A combination of the pattern of tile drain arrangement, such as the gridiron and herring bone (*see* Fig. 6).

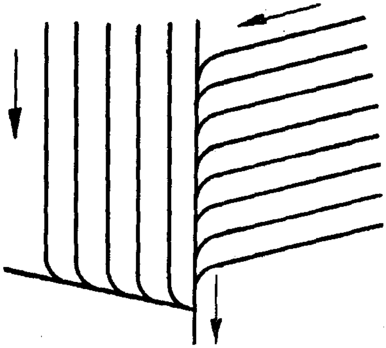


Fig. 6 Composite Pattern

3.2.2.4 *Random pattern* — An irregular system mostly used for draining isolated wet places in the field or to tap springs. Often a combination of types and patterns are used in this system (*see* Fig. 7).

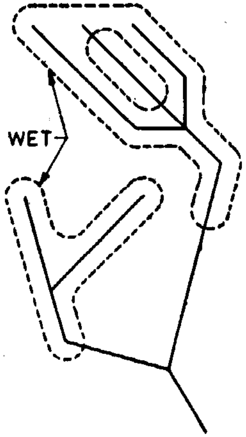


FIG. 7 RANDOM PATTERN

3.3 Alignment and Location of Drains

3.3.1 Where there are distinct natural direction of ground water flow, the laterals can be best laid perpendicular to the main flow direction as this will be most effective in intercepting the flow.

3.3.2 For flat and nearly flat areas, the lateral drains are preferably to be installed in the direction of the main slope of the field (if any). This would mean approximately equal depth of drains all over the field.

3.3.3 In large drainage system, the main drain should follow the natural valley.

3.4 Outlet — The following types of outlet for tile drainage are used:

a) Gravity, and
b) Pumping.

3.4.1 The gravity outlets include constructed ditches, natural streams, lakes, vertical drains, etc. For outlets into ditches, a non-perforated pipe of 3 to 5 m length (*see A* in Fig. 8) is recommended with the discharge end at least 30 cm above the normal water level. The end of the outlet shall be provided with a flap or cap cover with mesh which would cover 20 percent of open area having aperture size of 5 to 10 mm each side or diameter. The vertical drain or drainage well (*see* Fig. 9.), is suitable only for special conditions where a porous soil or an open rock formation exists.

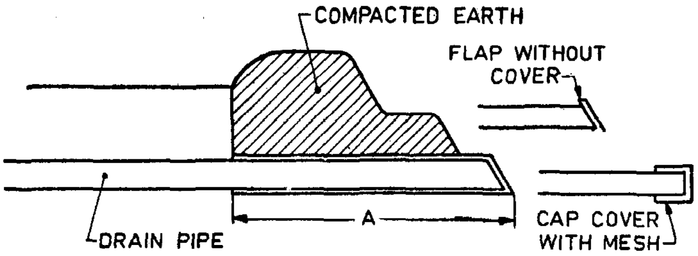


FIG. 8 GRAVITY OUTLET STRUCTURE FOR DITCHES

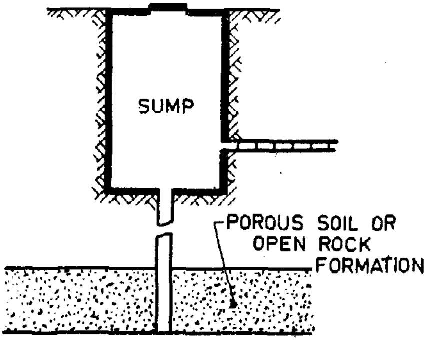


FIG. 9 GRAVITY OUTLET IN VERTICAL DRAINS

3.4.2 The pumping outlet (*see* Fig. 10) should have facilities for storing water, such as a sump or an open ditch. Where automatic controls are avilable, as with electric motors, the size of the sump need not be as for manually-controlled power units.

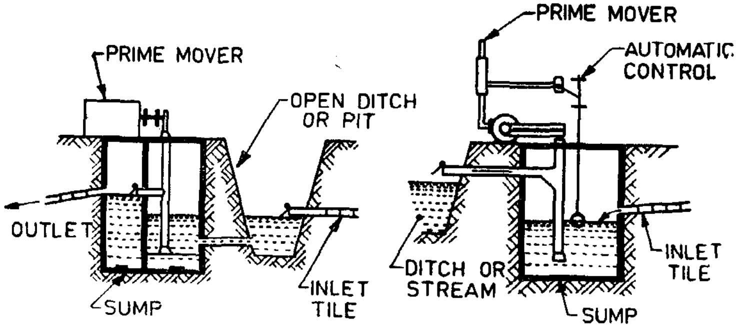


FIG. 10 PUMP OUTLET FOR TILE DRAINS

4. MATERIAL

4.1 Tiles — The tiles (pipes) of clay, concrete, plastics, asbestos cement, or of other materials of acceptable quality shall be used. The tiles shall meet the requirements of the relevant Indian Standards, such as IS : 8967 (Part I)-1978*, IS : 8968-1978†, IS : 9271-1979‡ and IS : 9633-1980§.

4.2 Cover Material — Cover materials are applied to pipe drains mainly for two purposes:

a) Water-conducting function, that is, to facilitate the water flow into the drain, and

b) Filtering function, that is, to prevent the entry of soil particles into the drain.

NOTE — The cover material can be applied both by machine or manually. In case of manual laying, it could be completely enveloped. In the case of stable soils (clay content of 20 percent or more) pipes shall stay reasonably clean without cover materials, if drains were installed under favourable (dry) conditions and drain pipes are covered with stable top soil.

4.2.1 *Cover Material in Bulk* — The cover material may be of various types. The bulk materials are usually applied as a cover material only, that is, they are spread on top of the drains, though a complete envelope is advisable because of its filtering function. With the modern mechanical drainage laying methods, it is not generally possible but can be applied manually.

4.2.1.1 *Organic material* — Materials, such as straw, hay, maize cobs, wood chips and saw dust are used. These materials are having poor filtering function.

4.2.1.2 *Sand and gravel material* — These are commonly used for low cohesive soils (in arid and semi arid areas). These have to be properly graded for the specific soil condition of the location. If these are placed all around the pipe, then would serve both the functions of the cover materials.

4.2.1.3 *Synthetic materials* — Materials, such as polystyrone flocks (glass wool) with very low specific mass are used.

4.2.2 *Cover Materials on Roll or Mat*

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*Specification for farm drainage clay tiles : Part I Tiles with open joints.

†Specification for farm drainage concrete tiles.

‡Specification for farm drainage plastics pipes.

§Specification for farm drainage asbestos cement pipes.

4.2.2.1 *Materials having both filtration and good water entry properties* — These materials, such as glass fibre sheet and typer or terim can easily be formed into a complete envelope around the tile or pipe. Generally, in this category, the materials are having good filtering properties but within short period of time exhibit poor water-conducting tendency. It would, therefore, be desirable to use combination of bulk and roll material. Where soil and water does not have iron problem this combination would be more efficient.

4.2.2.2 *Special materials used to reduce the entrance gradient* — These materials, such as thin plastic sheet equal to trench width, laid all along the length over the pipe directly, or over the cover material are impermeable to water. The use of this would reduce the thickness of cover material at the top of the tile or pipe. The layout of the material is shown in Fig. 11.

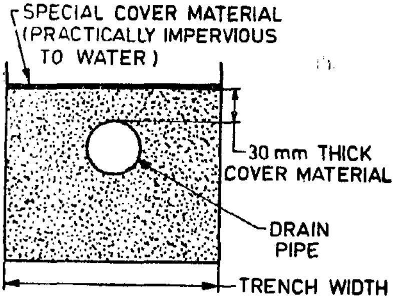

SPECIAL COVER MATERIAL (PRACTICALLY IMPERVIOUS TO WATER)
30 mm THICK COVER MATERIAL
DRAIN PIPE
TRENCH WIDTH

FIG. 11 CROSS SECTION OF TRENCH WITH SPECIAL COVER MATERIAL

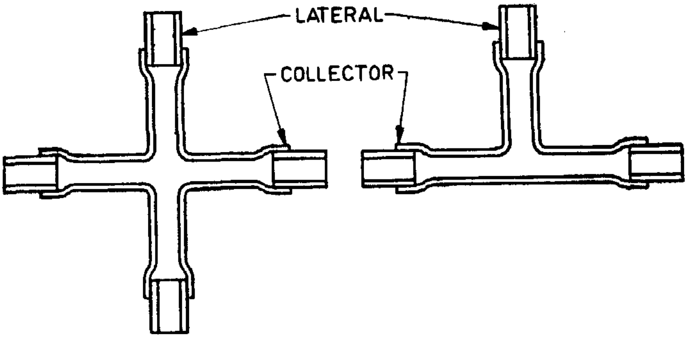
4.2.3 *Pre-Envelope of Drain Pipes* — Pre-enveloping is applied only with smooth or corrugated plastic pipes. The materials used are generally factory enveloped. The materials could be either in sheet or hose form. The total form simply to be slip on the pipes and the other form is to be rapped fixed. These materials are generally glass fibre, nylon tissues or other synthetic materials. The organic materials like flax straw, cereal straw, coir fibre, rope, etc, of 20 to 30 mm thickness could be rapped.

5. JUNCTIONS

5.1 Blind Junctions -- Blind junctions are provided between the lateral and the collector pipes. In these junctions it is an advantage to have the lateral at a higher level than the collector and to make the connection in the top of the collector. These junctions are of the following two types (*see* Fig. 12).

5.1.1 *Cross Piece Connection* — For this type of junctions, special junction pipes are required (*see* Fig. 12A).

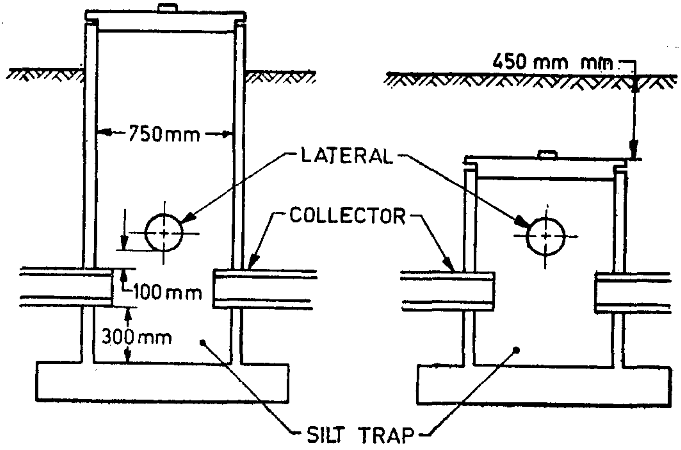
5.1.2 *T-Piece Connection* — This is used when a single lateral is entering the collector (*see* Fig. 12B).



12A Cross Piece 12B T Piece

FIG. 12 BLIND JUNCTIONS

5.2 Inspection Chamber Junction Boxes — These boxes are usually provided with silt traps. It is desirable for non-singular system to provide junction boxes at suitable intervals for collecting the silts and sometimes for cleaning. The chambers are made of concrete cast at the site, or built of bricks or pre-fabricated. The junction boxes may be of two types (*see* Fig. 13).



13A Cover Above Ground 13B Buried Cover

FIG. 13 INSPECTION CHAMBER JUNCTION BOX

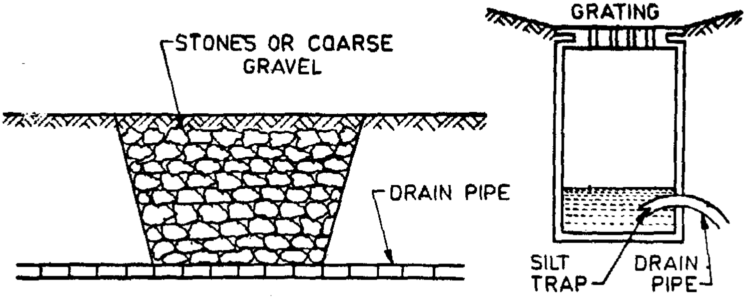
5.2.1 *Cover Above the Ground* — The layout of this type is shown in Fig. 13(A).

5.2.2 *Burried Cover* — The layout of this type is shown in Fig 13B. In this case with certain modifications one can use the same structures for excess irrigation water outlet or excess rainfall outlet.

5.3 Surface-Water Inlets — These structures are built in the places where surface water is likely to accumulate. There are two possible ways this can be done.

5.3.1 *Blind Inlets* — It consists of a cover of stones and gravel extending from the ground surface to the drain pipe (*see* Fig. 14 A).

5.3.2 *Open Inlets* — This is generally provided with a silt trap and a protection cover on the ground surface by some form of grate (*see* Fig. 14 B).



14A Blind Inlet 14B Open Inlet

FIG. 14 SURFACE-WATER INLETS

6. DESIGN

6.1 Capacity of drain system and depth, spacing and grading of tiles (pipes) shall be designed on the basis of the soil, crop to be grown, rainfall intensity, irrigation facilities and salinity of soil and ground water. An Indian Standard code for design of tile (pipe) drain system is under preparation. Till this standard is publihed, the design criteria shall be as agreed to between the concerned parties.

7. TRENCHING

7.1 Trench Width — The bottom width of the trench should be adequate to provide the following:

a) clearance for joining the tile (pipe) in the ditch with standard fittings;

b) bedding conditions suitable to support the load on the tile (pipe) as specified, and

c) minimum width of 75 to 150 mm on both sides of the tile (pipe) for an envelope or filter.

7.1.1 The trench width should be such that the soil load does not seriously deflect the plastic pipes. Try to have lesser width as far as possible. In wide trenches, special precaution should be taken to protect the pipes.

7.2 Trench and Cover Depth — The minimum depth of cover over the tile (pipe) and the maximum trench depth are influenced by a number of factors such as, the type of bedding, the nature of the trench bottom on which the tile (pipe) will be laid, the width of the trench, amount of bedding compaction on the sides of the tile (pipe), the mass and type of backfill, the tile (pipe) stiffness and any live load. However, some suggested cover depth for various types of soil is given below.

7.2.1 *Mineral Soils* — The recommended minimum cover to protect the tile or pipe from crushing due to live load is 0·6 m.

7.2.2 *Organic Soil* — The recommended minimum cover to protect the tile or pipe from crushing due to live load is 0·7 m. If water level controls are not provided in the drainage system to hold subsidence to a minimum, the depth of cover should be increased to 0·9 m.

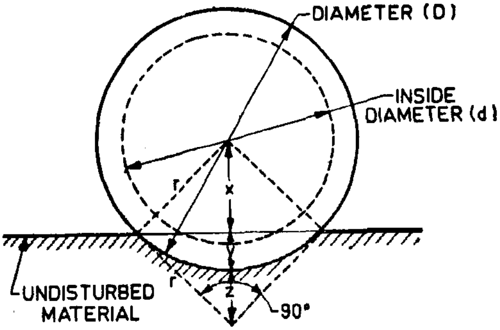
NOTE — These minimum depths are recommended to prevent crushing of the tubing by normal agricultural vehicle loads. Other drainage factors, such as those encountered with salinity control in arid irrigated lands may require minimum depth of 1·8 m.

7.3 Unstable Trench Walls — Unstable or fluid soil conditions encountered in the trench wall, such as found by excavation below a ground water level or in a saturated sand, may cause tile or pipe failure by caving of the trench side walls. Under these conditions, means shall be provided to protect the tile or pipe from deformation or floating until it has been properly laid and blinded. In some cases a longer trencher shield behind the shoe may protect a greater length of the trench.

8. BEDDING

8.1 Trench Bottom — The trench bottom should be smooth and free from exposed rock. A specially shaped groove is recommended in the trench bottom where a gravel envelope is not specified. The groove provides support for the tile or pipe and a means of maintaining alignment during installation. The groove may be semicircular, trapezoidal shaped or a 90° ‘ V ’ as shown in Fig. 15.

NOTE — With the 90° ‘ V ’ void under the tile or pipe is advantageous for load bearing, but may cause undermining on steep grades. Under these conditions the bottom of the trench may be shaped to fit the tile (pipe).



D = 80, 100, 125, 150 or 200 mm
d = 20 percent less than D
$r = D/2$
$x = 0{\cdot}707\,r$
$y = 0{\cdot}293\,r$
$z = 0{\cdot}414\,r$

FIG. 15 DIMENSIONS FOR A 90° 'V' GROOVE

8.2 Unstable Trench Bottom — Where an unstable trench bottom condition is encountered such as in fine sandy soils or in quick sand, extreme care shall be taken to keep this material from entering into the tile or pipe and to provide a firm foundation for the tile or pipe. For drainage of unstable lands a fast moving trencher should be used that disturbs the inplace material as little as possible. The following precautions may be helpful when draining these soils.

8.2.1 *Dry Profile* — Install tile or pipe only when soil profile is in its driest possible condition.

8.2.2 *Providing a Firm Foundation* — If a significant depth of the unstable soil material is encountered, it should be removed and replaced with a foundation and bedding of processed stone or processed gravel, suitably graded so as to act as a mat into which the unstable soil will not penetrate. The depth of this processed mat for foundation and bedding should depend upon the severity of the trench bottom soil condition. Install such special foundation and bedding material in a maximum of 150 mm layers and compact.

8.2.3 *Foundation Cradle* — Where stabilizer materials do not provide adequate support, tile or pipe should be placed in a 90° rigid 'V' prefabricated foundation cradle. The cradle shall provide rigidity and furnish continuous support throughout the entire length.

8.3 Stony Trench Bottom — If the bottom of the trench contains stones in excess of 38 mm in diameter, the trench should be over-excavated 150 mm and refilled to grade under and around the tile or pipe with a 150 mm cushion of acceptable bedding material.

8.4 Over-Excavation — Fill any area of over-excavation below the grade line with proper bedding material. Plane and shape the tile or pipe bed to grade. For drainage of irrigated lands, backfill over-excavated portions of the trench with a designed gravel envelope material with adequate hydraulic conductivity to allow water movement into the tile or pipe openings.

8.5 Rock Excavation — When the tubing is to be laid in a rock cut, the trench should be over-excavated to a depth of 150 mm below grade level and this space filled to grade with gravel or other suitable material and taped sufficiently to provide a firm foundation. The trench within a rock cut should be filled with designed bedding or envelope material.

8.6 Cover Material

8.6.1 In humid type drainage, install cover material for bedding support when it is not feasible to form a groove in the trench bottom. In arid-type drainage install an envelope to facilitate ground water flow into the drain. The material also serves as proper bedding support (*see* also **4.2**).

8.6.2 Place the envelope material carefully to form an even, firm bedding without disturbing the tile or pipe grade and alignment. Exercise due care to ensuret hat no mud, excavated material or foreign matter is mixed with the envelope material during the installation. No special compaction of gravel envelope material is necessary except as required for ensuring a firm and even bedding for the tile or pipe.

8.6.3 *Filters and Filter Material* — A filter is used to restrict fine particles of silt and sand from entering the drain. A sand and gravel envelope designed as a filter may be used. Artificial prefabricated filter material can also be used. A filter is required for base materials such as uniform fine to medium sands where high velocities can develop that will move the sands into the drain. Gravel envelopes are not normally designed as filters, but because they consist of well-graded material they do act as partial filters. Prefabricated non-bio-degradeable filter materials such as fibre glass, spun bonded nylon fabric and plastic filter cloth may be used instead of sand and gravel type filter. During installation protect all open joints and perforations with material that will not stretch excessively. Take care not to damage the material during installation. Repair any damaged areas before backfilling.

NOTE 1 — There filters shall be specified to be compatible with the soil type that encompass the tile or pipe since protective filters can plug and decrease the inflow capability. Where fibre glass filter material is used, it shall be manufactured from borosilicate type glass and the manufacturer shall certify that it is suitable for underground use. The fibres should be of variable size, with some larger fibres intertwined in the mat in a random manner.

NOTE 2 — Vegetative filter material such as straw, hay, corn-cobs, woodchips, sawdust and coconut fibre are not recommended for use with flexible pipes because such pipes depend on the development of lateral support and these soft materials may not provide the necessary lateral support.

8.7 Pockets of Non-cohesive Soil — Use nonperforated tile or pipe where small pockets of noncohesive soil are encountered, unless special envelopes or other means are used to stabilize the soil.

9. CONSTRUCTION

9.0 The construction could be manual or mechanical.

9.1 Manual Construction — The steps envolved in manual construction are given below:

a) Layout and excavation of trench of required depth (*see* Fig. 16) and gradient,

b) Installation of tiles (pipes) in the trench with or without cover material, and

c) Backfill of the trench with excavated soil.

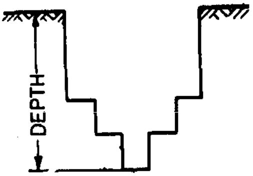
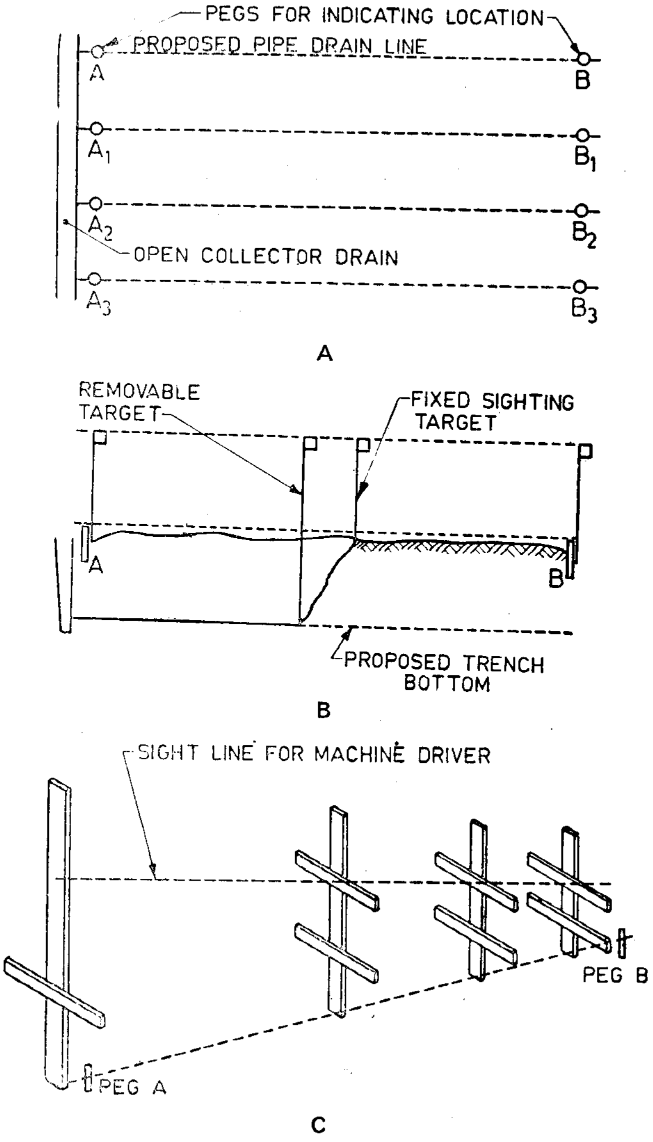


FIG. 16 EXCAVATION OF TRENCH

9.1.1 *Controlling Direction and Gradient* (*see* Fig. 17)

9.1.1.1 Grade stakes to govern alignment, direction and grade should be set 30 m or less apart on straight lines and 15 m or less on curve. They should also be set at all intersections of tile mains and points of grade change. Grade stake elevations should be determined with an engineer's level.



A = Location and depth of proposed pipe drain pipe
B = Length section of *A*—*B*, with the use of sighting targets for checking trench depth
C = Length section *A*—*B*, with machine sighting target

FIG. 17 MARKING ALIGNMENTS AND LEVELS

9.1.1.2 Targets should be used as a guide to keep the tile trench bottom to exact grade on all tile line construction. A minimum of 4 targets should be set along any given line of continuous grade. Key targets shall be set at 150 to 200 m intervals, or at points of change in grade. Intermediate targets shall be set in correct position by carefully sighting between key targets. Each target shall be checked for depth of cut as indicated by its respective grade stake.

NOTE — String lines and wires shall be used in place of targets if care is exercised to keep them tight.

9.1.1.3 Trench alignment on straight lines shall be excavated true to the lines as staked. On curves the trench shall be excavated on a true curve and not on chords with sharp turns at the stakes.

9.1.1.4 Starting point for trenching shall be at the outlet and progress upstream.

9.1.2 *Correction for Over-Digging* — Correction for over-digging shall be accomplished by filling with either gravel or well-pulverized soil. The fill shall be tamped sufficiently to provide firm foundation. The bottom of the trench shall again be planned and shaped to the grade.

9.1.3 *Construction Features in Sandy Soil* — When sandy soils are encountered, special construction features are required depending upon the type and conditions of the sand as follows.

9.1.3.1 In fine sandy soil where the trench bottom is stable clay soil, the following recommendations should be followed:

a) lay the tile to secure a snug fit, and

b) Cover with the paper or other durable material to prevent the fine material from entering the tile line.

9.1.3.2 In fine sandy soils where the trench bottom is unstable or in soils containing quicksand (water saturated sand under hydraulic pressure) extreme care shall be taken to keep sediment from entering the tile and to provide a firm foundation for the tile. The following factors should be observed when draining these soils:

a) Construct the tile drains only when soil profile is in driest possible condition;

b) Lay the tile to secure a snug fit;

c) Use stabilizing materials under the tile;

d) Use an envelope material to cover the remainder of the tile;

e) When the objective is to extend tile through a quick sand pocket, self sealing sewer pipe or continuous rigid pipe may be used in place of drain tile. Where metal pipe is used, joints should be properly wrapped.

f) Where stabilizer materials do not furnish adequate support, the tile should be placed in a cradle. A cradle is constructed by placing wooden planks in the bottom of the ditch and nailing wooden strips along the top edges to form a trough for the tile. The width of the plank should be approximately equal to the outside diameter of tile. Junctions of planks and strips are staggered to give rigidity to the cradle and furnish continuous support throughout its entire length. Occasionally, it is necessary to place the cradle on pilling. Pilling is constructed by driving pairs of posts along the edges of the trench. Posts should be driven deep enough into the subgrade material to become firm. Cross timbers of 50 × 50 mm shall be nailed to opposite posts to support the cradle.

g) Sheet pilling, pumping, freezing and various other means have been used to install tile in unstable soils.

9.2 Mechanical Construction — After layout and alignment the rest of the operations are done automatically by the machine. The 'laser beam' is also used in more sophisticated systems for controlling the grades. For this system also the operation starts from down stream end. The mechanical system may be either trench type or trenchless type.

9.2.1 In the trench type system, the machine may be either continuous-excavating type or back-acting type. In both the cases, first trench of required size is made then the tiles (pipes) are laid along with the cover material and finally the trench is backfilled.

9.2.2 In trenchless type system, all the operations are done in sequence continuously as the machine moves forward.

10. PLACEMENT OF TILES

10.1 Tile shall be laid true to line and grade and firmly embedded in the bottom of the trench. The tile shall be kept heaped up to within a metre of the finished trench. If necessary, the tile shall be rotated so that the gap left in the tile is uniform. The bottom of the trench shall be rounded so that the tile can be embedded in the soil for 60 to 90° (1/6 to 1/4 of its circumference).

10.2 The constructed grade shall allow the tile line to provide the capacity required to drain the area. A slight decrease in grade from the design may be tolerated if the required capacity is less than actual capacity. The deviation from designed grade shall be gradual over a distance of 10 to 18 m. A deviation of 8 to 10 percent of internal diameter shall not appreciably reduce the capacity of the line.

10.3 The tile should be kept clean while laying. All soil or debris in the tile should be removed before the next tile is laid.

10.4 At the end of each day's work the end of the tile line should be covered to prevent sediment or debris from entering the line in the event of rain. The upper end of all tile drain should be tightly covered with a manufactured end tile, plastic plug, brick or other suitable material. The open trenches should be backfilled each day.

10.5 Use non-perforated tiles when passing through areas where root growth may create an obstruction in the line.

10.6 Tile Openings — In all soils, tile joint spacings shall be large enough to permit entry of designed flow and small enough to prevent entry of sediments. The joint spacing between individual tile shall be about 3 mm, unless the soil is sandy or muck. Most butt-end drain tile shall have an adequate opening for water entry. In unstable soils the joints spacing shall be as small as possible to prevent inflow of fine sand. Where joint spacings are more than 3 mm in sandy soils and 6 mm in clay soils, the opening shall be covered with pieces or broken tile or other durable material. In case the tiles are not square on the ends, they may be rotated so that the widest opening shall be on the bottom and the narrowest opening on top.

10.7 Junctions — Manufactured junctions (*see* also **5**) of proper size shall be installed. The junction between the lateral and the main shall be carefully made to ensure a smooth and tight connection. The lateral may enter the main at a 90° angle, but on some lines a 45° angle may be more convenient. Because of ease and convenience in installation and the resulting improvement of workmanship, the 90° or the T-junction is preferred. Junctions shall be made so that the centre of the lateral is not lower than the centre of the main. When laterals are much above the main they shall be gradually lowered to enter the main at or near the centre. Manufactured junctions are more satisfactory than those fabricated in the field. If manufactured junctions are not available they shall be carefully made and sealed with mortar which shall be allowed to harden before backfilling.

10.8 Checking Grade — Immediately after installation and before backfilling, the tiles shall be checked for grade, alignment and other design specifications. Allowable variation from true grade shall be within reasonable limits. A variation of 0·12 mm per mm of tile diameter for sizes up to 250 mm shall be allowed.

10.9 Blinding — Place selected bedding material, containing no hard object larger than 38 mm in diameter in the trench to a recommended minimum depth of 150 mm over the tile or pipe. Compaction of bedding material along the tile or pipe side walls is beneficial in reducing deflection of plastic pipe. Except in those areas where chemical deposits in and around the tile are a problem, the bedding material should be top soils or other porous material. Hold the tiles in place in trench until secured by blinding.

10.10 Backfilling — Place the backfilling material so that displacement or deflection of the tile should not occur. Avoid large stone and dry clods that cause concentrated direct load on the tiles. The trench shall be backfilled as soon as possible after blinding.

10.11 Envelope and envelope material, and filter and filter material wherever required shall be used.

11. ASSESSMENT OF PERFORMANCE OF SYSTEM

11.1 The performance of the proper installation of the whole system shall be assessed in accordance with the Indian Standard 'Method for Assessment of performance of tile drain system (under preparation)'. Till the publication of this standard the method shall be as agreed to between the concerned parties.

Note — The testing of the system may be done before the actual installation on pilot basis over major soil groups. After satisfying with the performance the whole system may be laid.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

INDIAN STANDARDS
ON
FARM DRAINAGE TILES

IS:	
8967 (Part I)-1978	Farm drainage clay tiles: Part I Tiles with open joints
8968-1978	Farm drainage concrete tiles
9271-1979	Farm drainage plastic pipes
9633-1980	Farm drainage asbestos cement pipes